PATENT SPECIFICATION

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Int. Cl.:—B 60 g 11/30.

COMPLETE SPECIFICATION

DRAWINGS ATTACHED

Hydro-Pneumatic Suspension for Wheeled Vehicles

I, VICTOR LANGEN, a German citizen, of 49 Klosterstrasse, 4 Dusseldorf, Germany, trading as Langen & Co., do hereby declare the invention, for which I pray that a patent may be granted to me, and the method by which it is to be performed, to be particularly described in and by the following statement :—

This invention relates to hydro-pneumatic suspensions for wheeled vehicles.

It is known to suspend vehicles hydro-pneumatically by providing for each of the vehicle wheels a hydraulic cylinder on the vehicle frame, each of the wheels being fastened to the piston rod of the hydraulic cylinder associated with it, while the upper end of the cylinder is connected to a hydro-pneumatic pressure accumulator. It is further known, in the case of such an arrangement, to connect the hydraulic cylinders of two wheels of the vehicle, for example the front and rear wheels of the vehicle on one side of the vehicle, by a liquid pipe. The invention aims at an improvement to such an arrangement with the object of preventing the vehicle from adopting an oblique position in the case of a change in the static load, for example due to the placing of a load which acts principally on one axle.

According to the invention, a hydro-pneumatic suspension for wheeled vehicles, wherein each of the vehicle wheels is connected to the piston of a hydraulic cylinder, one cylinder to each wheel, the top pressure spaces in the cylinders being connected to a hydro-pneumatic pressure accumulator, the cylinders associated with two wheels being mutually connected by a liquid pipe, is characterised in that one of the cylinders of such an interconnected pair of cylinders is constructed as a single-acting cylinder and the other cylinder of a said pair is constructed as a double-acting cylinder, and that the said interconnecting liquid pipe connects the top pressure space in the single-acting cylinder to the bottom pressure space in the double-acting cylinder.

Thus, the effective top piston surface of the single-acting cylinder and the bottom piston surface of the double-acting cylinder stand in a specific ratio, the value of which is determined by the position of the point of attack of the load with respect to the cylinders; it is therefore convenient in many cases to make the said two piston surfaces of equal magnitude.

Between each of the cylinders and its pressure accumulator, throttle elements may be arranged in manner known *per se*. An adjustable throttle element may be disposed in the said liquid pipe. A further pressure accumulator may be connected to the bottom pressure space of the double-acting cylinder.

Embodiments of the invention are shown, diagrammatically, in the accompanying drawings, wherein :—

Fig. 1 shows one embodiment of the invention;

Fig. 2 shows another embodiment of the invention; and

Fig. 3 shows a modification of the embodiment shown in Fig. 2.

In Fig. 1 a front wheel 1 of a vehicle is connected to a piston 2 in a single-acting cylinder 3, that is a cylinder having a pressure space at only one side of the piston, the top pressure space 3' of the cylinder being connected by a pipe 4 to a hydraulic pressure accumulator 5. A rear wheel 9 of the vehicle is connected to the piston 8 in a double-acting cylinder 7, that is a cylinder having pressure spaces at both sides of the piston, the top pressure space being connected by a pipe 10 to a hydraulic

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Price 7p

pressure accumulator 11. The top pressure space 3′ in the cylinder 3 is also connected by a pipe 6 to the bottom pressure space 7′ of the cylinder 7 (in this specification the term "bottom", in respect of the cylinder, the pressure spaces therein and the piston, means the side of the piston which is connected to the piston rod, whilst the term "top" refers to the other side of the piston).

In the embodiment of the invention shown in Fig. 2, a throttle element 12 is placed in the pipe 4, a throttle element 13 is placed in the pipe 10, and a throttle element 14 is placed in the pipe 6. A pressure accumulator 15 is connected to the pipe 6 between the throttle element 14 and the bottom pressure space 7′ of the cylinder 7. The throttle elements 12, 13 and 14 may be of any suitable kind; in the embodiment shown in Fig. 2 they consist of two parallel-connected, oppositely-oriented non-return valves R1 and R2 and two adjustable throttle points D1 and D2.

Fig. 3 shows a modification of the embodiment shown in Fig. 2, comprising the supplementation of the right-hand side of Fig. 2, that is the rear wheel portion, by a level regulating device. A level regulating valve 16 is connected fixedly to a part of the vehicle chassis (in the present case to the cylinder 7), and it connectes the top pressure space 7″ of the cylinder 7, by way of a pipe 17, either to a pipe 18 or to a pipe 19 depending upon the direction of actuation. The pipe 18 is connected to a pressure source 20, and the pipe 19 is connected to a storage container 21.

The actuation of the valve 16 is effected by way of a valve slide 22 which is connected by way of a spring element 23 to a bracket 25 secured to the piston rod 24 of the piston 8 in the cylinder 7.

The apparatus operates in the following manner:—

When the vehicle is unladen, the pistons 2 and 8 assume, for example, the positions shown in Figs. 1 and 2. If the vehicle is then loaded in such a way that a load P acts in the axial direction of the cylinder 7, then the pressure in the top pressure space 7″ increases; consequently liquid is displaced through the pipe 10 and the throttle element 13 into the pressure accumulator 11. Corresponding to the quantity of liquid so displaced, the piston 8 moves upwards by a specific amount, for example so that the top piston surface 8″ then assumes the position indicated by a broken line in the cylinder 7 in Fig. 2. Due to the greater volume thereby created in the bottom pressure space 7′, liquid will flow into said space 7′ from the top pressure space 3′ in the cylinder 3. Since the liquid pressure in the pressure accumulator 5 was of equal value to the liquid pressure in the top pressure space 3′, no liquid can be drawn out of the pressure accumulator 5. Since, in this example, the top piston surface 2′ of the piston 2 is of equal magnitude to the bottom piston surface 8′ of the piston 8, the piston 2 moves upwards by the same amount as the piston 8, so that its top piston surface 2′ assumes the position indicated by the broken line in the cylinder 3. The two cylinders 3 and 7 therefore descend equally with respect to the vehicle wheels 1 and 9, that is the vehicle frame does not assume an oblique position due to the load P. In the case of a downward movement of the piston 8 in the cylinder 7, the process occurs in inverse manner.

In the above description, only the effect of a static load change has been described. Under dynamic travelling conditions, for example when travelling over a corrugation 26 in the ground, the mutual influence between the cylinders 3 and 7 may be undesirable. It is largely obviated by the inertia of the masses which have to be moved, and by the damping properties of the system. The liquid in this case is principally displaced into, or removed from the corresponding pressure accumulators 5, 11. A further means of reducing undesirable movements is constituted by the throttle element 14 incorporated in the pipe 6. By means of this throttle element 14, the oil stream between the two cylinders is sufficiently throttled so that, although a slow pressure equalisation is possible, rapid passage of a large quantity of liquid is prevented. The prevention of cavitation in the bottom pressure space 7′ in the cylinder 7 may be achieved by the pressure accumulator 15 which covers the alternating liquid requirement in the annular space 7′ in the case of strong throttling in the pipe 6 by the throttle element 14. The throttle elements 12 and 13 serve for adjusting favourable damping properties in the suspension elements.

In case it is also required to maintain constant ground clearance of the vehicle body, it is advisable to use a level regulating valve 16 as shown in Fig. 3, in which case the presence of an adequately dimensioned liquid source in the vehicle is assumed. The adjustment of the valve slide 22 is effected as a consequence of relative movements between the cylinder 7 and the wheel 9. The transmission of these movements is effected by way of the spring element 23, which connects the valve slide 22 to the bracket 25 on the piston rod 24. If the wheel 9 springs rapidly in and out again, for example, due to the irregularity in the road, then these movements are absorbed by the spring element 23, due to the rapidity of such movements and to the

inertia of the valve slide 22, and they are not transmitted to the level regulating valve 16. Such a transmission is, on the contrary, performed only in the case of extremely slow movements. In such a case, a movement of the piston 8 towards the top of the cylinder 7 produces an adjustment of the level regulating valve 16 in such a way that liquid flows from the pressure source 20, by way of pipes 18 and 17, into the top pressure space 7″ in the cylinder 7, and thereby raises the latter until an equalisation is obtained. In the case of a movement of the piston 8 towards the bottom of the cylinder 7, a release of liquid out of the top pressure space 7″ occurs, by way of the pipes 17 and 19, into the storage container 21, likewise until an equalisation is brought about.

WHAT I CLAIM IS :—

1. Hydro-pneumatic suspension for wheeled vehicles, wherein each of the vehicle wheels is connected to the piston of a hydraulic cylinder, one cylinder to each wheel, the top pressure spaces in the cylinders being connected to a hydro-pneumatic pressure accumulator, the cylinders associated with two wheels being mutually connected by a liquid pipe, characterised in that one of the cylinders of such an interconnected pair of cylinders is constructed as a single-acting cylinder and the other cylinder of a said pair is constructed as a double-acting cylinder, and that the said interconnecting liquid pipe connects the top pressures space in the single-acting cylinder to the bottom pressure space in the double-acting cylinder.

2. Hydro-pneumatic suspension according to claim 1, characterised in that the top piston surface of the single-acting cylinder and the bottom piston surface of the double-acting cylinder are of equal magnitude.

3. Hydro-pneumatic suspension according to claim 1 or 2, characterised in that throttle elements are disposed in the connections of the top pressure spaces of the two interconnected cylinders to the respective pressure accumulators.

4. Hydro-pneumatic suspension according to claim 1, 2 or 3, characterised in that an adjustable throttle element is disposed in the said interconnecting liquid pipe.

5. Hydro-pneumatic suspension according to any one of claims 1 to 4, characterised in that the bottom pressure space of the double-acting cylinder is connected to a pressure accumulator.

6. Hydro-pneumatic suspension for wheeled vehicles, substantially as described herein and shown in the accompanying drawings.

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This drawing is a reproduction of the Original on a reduced scale.

Fig. 1

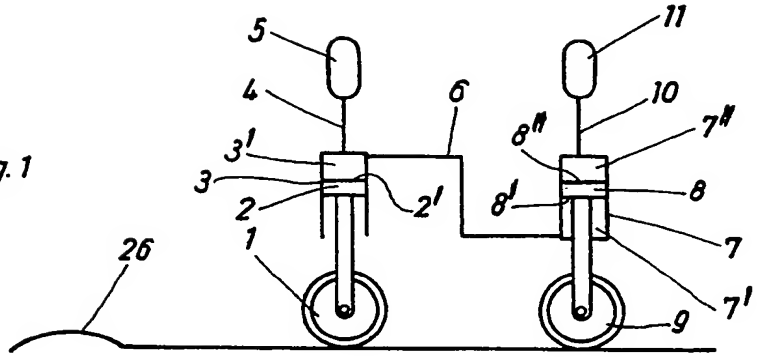

Fig. 2

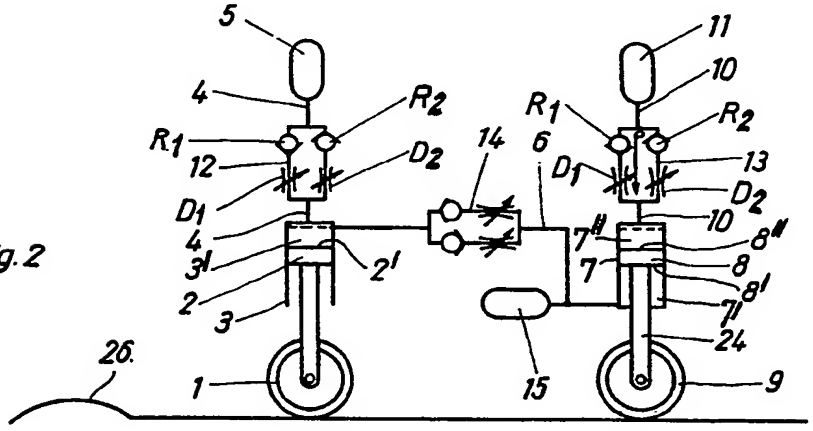

Fig. 3